Electronic Structure of the Stripe Phase in $(La_{1.28}Nd_{0.6}Sr_{0.12})CuO_4$

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The stripe phase [1,2], which has attracted considerable attention in connection with recent neutron scattering data from Nd-substituted $(La_{1.48}Nd_{0.4}Sr_{0.12})CuO_4$ (Nd-LSCO)[3], represents a new paradigm to think about charge carriers in a solid. Unlike conventional metals where the charge distribution is homogeneous, the stripe picture asserts that the charge carriers are segregated into one-dimensional domain walls. At the same time, the electronic spins in the domain between the walls order antiferromagnetically with a π phase shift across the domain wall. The possibility of charge segregation propensity and its implications on conduction as well as superconducting mechanism are at the heart of the current debate in high-T_c research. So far, little information about the electronic structure of the stripe phase is available. In this paper, angle-resolved photoemission data are reported for Nd-LSCO, a model compound where the evidence for spin and charge ordering is the strongest[3]. These results provide a phenomenological foundation to build a comprehensive theory on the charge and spin ordering in cuprates, and their relationship with superconductivity.

The ARPES data have been recorded at the beamline 10.0.1.1 of the Advanced Light Source[4]. In the spectral intensity plot (Fig. 1), integrated over 500 meV energy window of the Fermi level, panel (A) plots the raw data while panel (B) gives the four-fold symmetrized data. The spectral weight, when integrated over a large frequency window, represents the momentum distribution function n(k) weighted by the photoionization cross section. The high n(k) area is approximately confined within one-dimensional segments with the range of $|k_x| < \pi/4$ for any k_y or $|k_y| < \pi/4$ for any k_x (Fig. 1B). On the other hand, the low energy spectral weight (Fig. 2) is mostly concentrated near the $(\pi, 0)$ and $(0, \pi)$ region. It is also striking that there is little or no low energy spectral weight near the zone diagonal [(0, 0) to (π, π) direction], where the *d*-wave gap has nodes.

In general, the n(k) pattern allows one to determine the underlying Fermi surface that separates the occupied area from the unoccupied area. It is plausible that the four-fold symmetry seen in our experiment stems from two sets of orthogonal domains. For each domain, the Fermi surface is either the $|k_x| = \pi/4$ or $|k_y| = \pi/4$ lines. In this context, the Fermi surface observed can be understood as a superposition of two perpendicular Fermi surfaces arising from two different domains (Fig. 1D). Because the metallic stripes are ¼-filled at 1/8 doping, it is consistent with the occupied state being confined within $|k_x|=\pi/4$ and $|k_y| = \pi/4$.

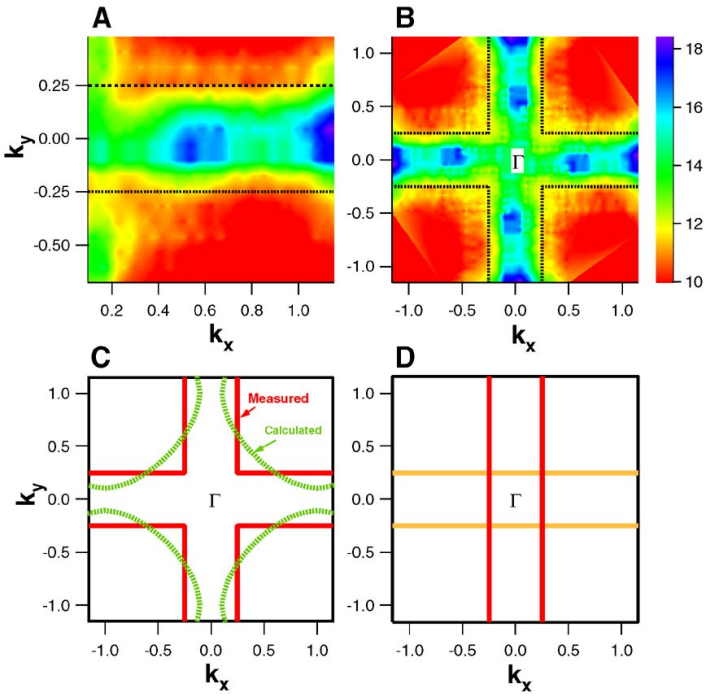

Fig. 1. Spectral weight integrated within 500 meV of the Fermi level, as a function of k_x and k_y. **A** is obtained directly from the raw data while **B** is obtained by symmetrizing **A** using four-fold symmetry. The dashed lines in **A** and **B** define the regions where the spectral weight is mainly concentrated. **C** depicts the underlying Fermi surface (solid line) obtained from **B** that encloses the high spectral weight region. The calculated Fermi surface for 2D CuO_2 plane is also shown (in dashed line) for comparison. **D** depicts the Fermi surface expected from two perpendicular 1D stripe domains in one-dimensional interpretation.

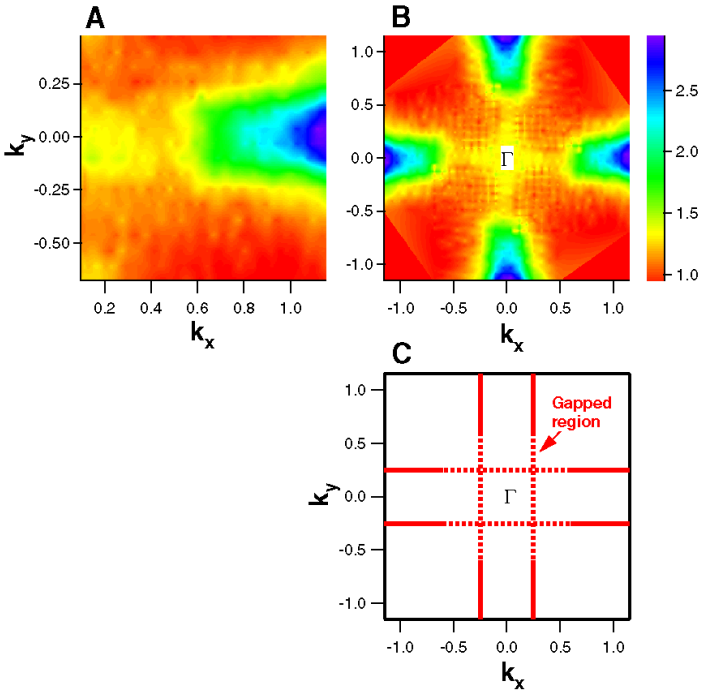

Fig. 2. Spectral weight integrated within 100meV energy window of the Fermi level, as a function of k_x and k_y. **A** is obtained directly from the raw data while **B** is obtained by symmetrizing **A** using four-fold symmetry. **C** illustrates the underlying Fermi surface where the gap may open; the dashed lines indicate the possible gapped region.

The data presented in the paper seem to present some apparent paradoxes. The persistence of the 1D-like character up to 500 meV or beyond (Fig. 1) is unexpected from theories that start with quasiparticles defined very close to the Fermi energy. The solution to this dramatic departure from the Fermi liquid paradigm appears to call for a different basic starting point. Instead of quasiparticles, one may start with stripes that are at least locally stable up to very high energy. Another paradox is related to the edge dispersion perpendicular to stripes. How can charges, which are already confined to stripes at energy scale of 500 meV, experience perpendicular motion with dispersion of 200 meV? Further theoretical work that can take into account the energetics of charge motion in an antiferromagnetic background and stripe potential and investigate the connection of the edge dispersion to the transverse stripe fluctuation is needed to address these issues.

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